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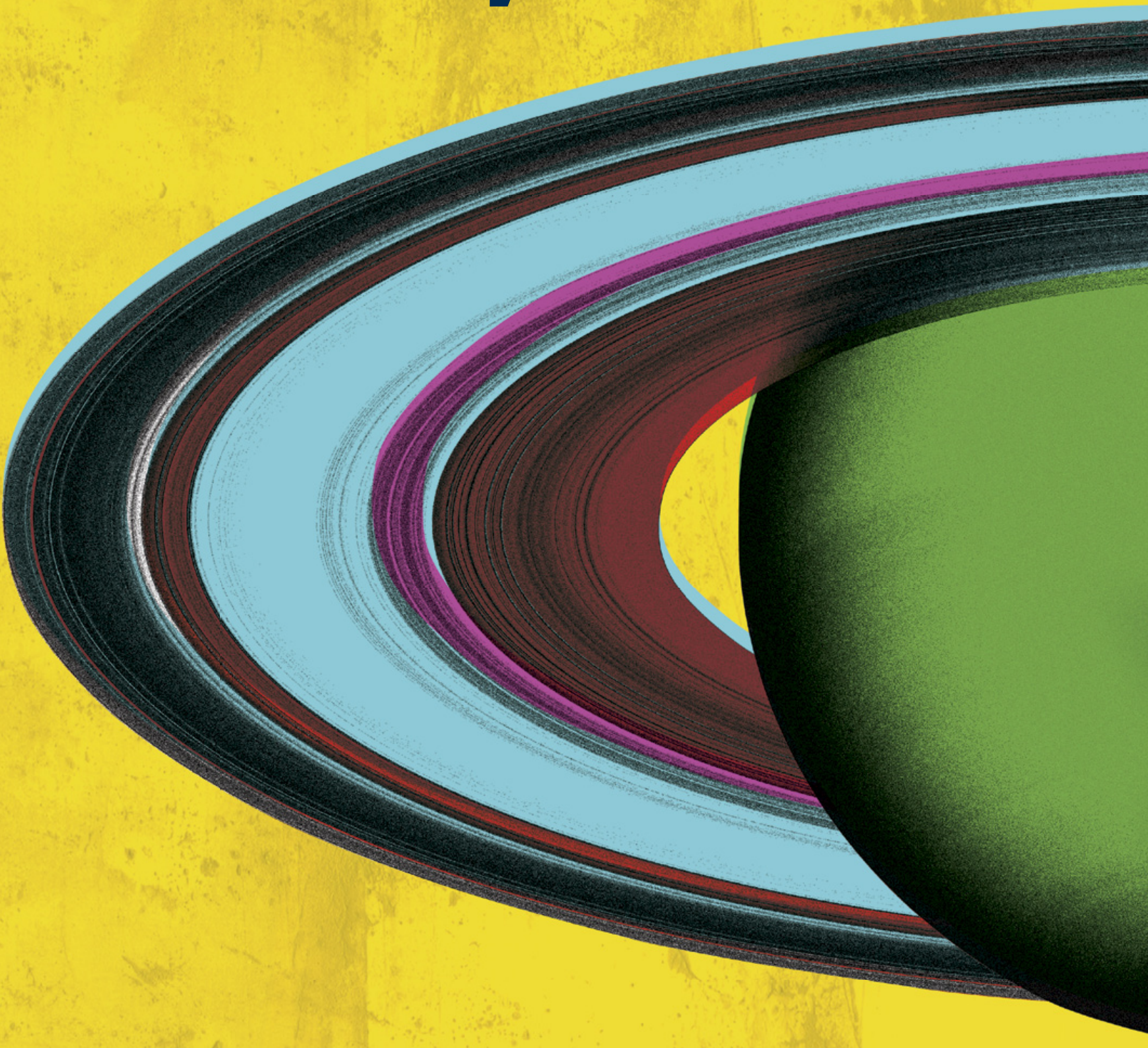
Teacher's Guide

Edexcel GCSE in Astronomy



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Contents

About the new specification

Consultation with professional astronomers and feedback from new and experienced astronomy teachers, told us that our previous specification was very much 'on the right track'. So in developing our new specification we have retained most of the original features. Our new GCSE in Astronomy consists of two units, with the same assessment weighting as the previous specification.

Unit 1: Understanding the Universe (external assessment, 75 per cent of the total mark).

Unit 2: Exploring the Universe (internal assessment with controlled conditions, 25 per cent of the total mark).

About Unit 1

Unit 1 includes four topics that match closely the previous specification: Earth, Moon and Sun; Planetary Systems; Stars; Galaxies, and Cosmology. The content of the fifth topic in the previous specification, *Observing techniques and space exploration*, has been incorporated into the new specification.

To help teachers in planning the course and students with their revision, each of the four topics is divided into three or four sub-topics. In addition, subject material within each sub-topic is listed as a set of individual Assessment Objectives. The generic heading 'Students will be assessed on their ability to:' precedes each item. The items directly related to *How Science Works* are shown in italics.

Our consultation showed us that, in general, most teachers and astronomers were very happy with the subject content of our GCSE. However, some material did need updating in light of recent astronomical advances and anticipated discoveries. Also, there was a desire to focus on practical, observational astronomy and `dilute' the astrophysical content slightly. To reflect these views, and to reduce the mathematical demands, we have made the following key changes.

New topic	New content	Deleted content
1: Earth, Moon and Sun	Eratosthenes's determination of Earth's circumference; names of principal lunar features; origin of the Moon (Giant Impact Hypothesis).	Seasons; tides; rockets and satellites; origin of lunar rilles, domes etc; temperature distributions within the Sun; ray diagrams for refracting and reflecting telescopes.
2: Planetary Systems	The size and scale of our Solar System; likely origins of planetary moons; Potentially Hazardous Objects (PHOs) and possible consequences of impacts (with Earth); exoplanets and their detection; the possible origins of water on Earth; methods of obtaining evidence for past and present life in our Galaxy; the Drake equation and Goldilocks zones.	Descriptions of planetary moons; Kepler's third law complex calculations; Newton's law of gravitation calculations.

New topic	New content	Deleted content
3: Stars	Planning and carrying out naked eye observations; popular asterisms; use of pointers as an aid to night-sky navigation.	Complex information obtained from a spectrum (for example differential rotation of the Sun).
4: Galaxies and Cosmology	Use of redshift formula and Hubble's Law; existence of dark matter and dark energy; active galactic nuclei (AGNs).	Radio astronomy techniques.

About Unit 2

For Unit 2 students need to plan, carry out, analyse and evaluate two observational projects. One project involves unaided (naked eye) observations and the other project requires a camera, a pair of binoculars, and a telescope (amateur or robotic). Other suitable aids to observation can also be used. For ease of implementation, most of the suggested project titles are identical to those in the previous specification. Both aided and unaided observations carry equal marks.

From 2009 onwards, internal assessment will be carried out under controlled conditions and this may affect the way you deliver this part of the specification. See the controlled assessment guide on *page* 26 for guidance on how to manage controlled assessments.

Delivery models

It is anticipated that a total of 60 hours' guided learning time will be needed to deliver the whole specification. This allows ample time for implementing the controlled assessment (Unit 2) and for revision sessions.

You can achieve this in either one (two 1-hour lessons per week) or two (one 1-hour lesson per week) academic years.

To help with your planning, we have divided Unit 1 into 48 smaller sub-topics, each of which could be taught in approximately one hour (with a considerable degree of flexibility). Two alternative delivery models are suggested below, but you are free to adapt or modify these in order to suit your students' needs and interests.

Suggested delivery models

Model A follows a more traditional route and prepares students for practical observation at an early stage in their studies. After a tour of the night sky, and an introduction to many of the astronomical objects that can be observed, the subject matter progresses logically outwards, dealing with our local astronomical neighbourhood (Sun, Moon, Solar System), and then further outwards to stars, the Milky Way, and the Universe at large.

Model B begins with a more astrophysical approach, examining the Sun as a typical star and then moving on to the physical properties and evolution of other stars. The Earth as a planet is introduced, and this develops into a study of what we can observe in the night sky from Earth. Our Solar System and its exploration are then covered, before moving outwards to galaxies beyond the Milky Way. Cosmology is then considered, and the course ends with an exploration of the Moon and some of the important interactions between the Moon, the Sun and the Earth.

Delivery model A	Delivery model B
3.1 Constellations	1.3 The Sun
3.2 Observing the Night Sky	3.3 Physical Properties of Stars
2.1 Our Solar System	3.4 Evolution of Stars
2.2 Comets and Meteors	1.1 Planet Earth
1.1 Planet Earth	3.2 Observing the Night Sky
1.2 The Moon	4.1 Our Galaxy – The Milky Way
1.3 The Sun	3.1 Constellations
1.4 Earth-Moon-Sun Interactions	2.1 Our Solar System
2.3 Solar System Discoveries	2.4 Exoplanets
2.4 Exoplanets	2.3 Solar System Discoveries
3.3 Physical Properties of Stars	2.2 Comets and Meteors
3.4 Evolution of Stars	4.2 Galaxies
4.1 Our Galaxy – The Milky Way	4.3 Cosmology
4.2 Galaxies	1.2 The Moon
4.3 Cosmology	1.4 Earth-Moon-Sun Interactions

Suggested delivery: Model A

Lesson	Content	Specification references
1	The night sky: an introduction to stars, constellations, clusters etc.	3.1 a–d
2	Observing constellations: pointers, seasonal constellations	3.1 e–f
3	Celestial coordinates: RA and declination, star charts, declination of Polaris	3.2 a–c
4	Circumpolar stars: analysis of star trail photographs	3.2 d–f
5	Practical observing: planning and carrying out naked-eye observations	3.2 g–n
6	Size, scale and nature of the Solar System: including scale models	2.1 a–c
7	Orbits: elliptical orbits; ecliptic; zodiacal band; perihelion etc.	2.1 d–i
8	Exploring the Solar System: characteristics of planets, space probes	2.1 j–m
9	Satellites and ring systems: origins of moons, planetary rings	2.1 n–o
10	Comets and the Oort Cloud: structure, origin and orbits of comets	2.2 a–f
11	Meteors: meteors, meteoroids, meteorites and micrometeorites	2.2 g–i
12	Collision course! PHOs and the hazards that they pose	2.2 j–m
13	The Earth from space: size, shape, rotation of the Earth	1.1 a, e–i
14	Observatory Earth: Earth's atmosphere, telescopes and observatories	1.1 b–d, j–p
15	Observing the Moon: principal features, lunar rotation	1.2 a–f
16	Exploring the Moon: seas, craters etc and their origin; project Apollo	1.2 g–k
17	Origin of the Moon: Giant Impact Hypothesis	1.2 l–m
18	The Sun: 'surface' and atmosphere	1.3 a–d
19	Sunspots: nature and appearance, solar rotation	1.3 e–h
20	The Sun's source of energy	1.3 i
21	Observing the Sun: solar observations at different wavelengths	1.3 j–k
22	Lunar phases: the Moon's orbit, phase cycle	1.4 a–d
23	Eclipses: mechanisms for, and durations of, lunar and solar eclipses	1.4 e–g

Lesson	Content	Specification references
24	Time: solar day, sidereal day, sun dials, Equation of Time	1.4 h–o
25	Aurorae: the solar wind, mechanism for aurorae	1.4 p–q, 1.3 l
26	The heliocentric Solar System: Copernicus, Tycho and Kepler	2.3 a–c
27	Galileo and his discoveries	2.3 d
28	Gravity: inverse square law nature of gravity, discovery of planets	2.3 e–f
29	The discovery of exoplanets: evidence for exoplanets, difficulties in finding them	2.4 a–b
30	The origin of water on Earth	2.4 c–e
31	Extra-terrestrial life? Drake Equation, Goldilocks zones	2.4 f–i
32	Collections of stars: clusters, binary stars	3.3 a–b
33	Magnitudes and distances: magnitudes, distances, the parsec	3.3 c–i
34	Variable stars: Cepheid variables, binary stars	3.3 j–m
35	Spectroscopy: classification of stars, temperatures and colours of stars	3.3 n–p
36	The birth of stars: emission nebula, absorption nebula, HR diagram	3.4 a–b, 3.3 q
37	The death of stars: planetary nebulae, supernovae, neutron stars, black holes	3.4 c–e
38	Observing the Milky Way: unaided and aided Milky Way observations	4.1 a–b
39	Structure of the Milky Way: size, shape and constituents of our galaxy; 21 cm radio waves	4.1 c–d
40	Classification of galaxies: types of galaxy, ‘Tuning Fork’ diagram	4.2 a–d
41	Active galaxies: types of active galaxy, AGNs and their evidence	4.2 e–h
42	Groupings of galaxies: local group, clusters and superclusters	4.2 i–k
43	Redshift: The Doppler principle, redshift-radial velocity relation	4.3 a–d
44	Quasars: nature and discovery	4.3 e–f
45	Hubble’s law: distance-redshift relation and estimation of the age of the Universe	4.3 g–h
46	Cosmic microwave background radiation: discovery and nature of CMB radiation	4.3 i–k
47	Dark matter and dark energy: possible nature and significance	4.3 l–m
48	The Universe – past and future: Big Bang, expanding Universe, future models	4.3 n–p

Suggested delivery: Model B

Lesson	Content	Specification references
1	The Sun: 'surface' and atmosphere	1.3 a–d
2	Sunspots: nature and appearance, solar rotation	1.3 e–h
3	The Sun's source of energy	1.3 i
4	Observing the Sun: solar observations at different wavelengths	1.3 j–k
5	Collections of stars: clusters, binary stars	3.3 a–b
6	Magnitudes and distances: magnitudes, distances, the parsec	3.3 c–i
7	Variable stars: Cepheid variables, binary stars	3.3 j–m
8	Spectroscopy: classification of stars, temperatures and colours of stars	3.3 n–p
9	The birth of stars: emission nebula, absorption nebula, HR diagram	3.4 a–b, 3.3 q
10	The death of stars: planetary nebulae, supernovae, neutron stars, black holes	3.4 c–e
11	The Earth from space: size, shape, rotation of the Earth	1.1 a, e–i
12	Observatory Earth: Earth's atmosphere, telescopes and observatories	1.1 b–d, j–p
13	Celestial coordinates: RA and declination, star charts, declination of Polaris	3.2 a–c
14	Circumpolar stars: analysis of star trail photographs	3.2 d–f
15	Practical observing: planning and carrying out naked eye observations	3.2 g–n
16	Observing the Milky Way: unaided and aided Milky Way observations	4.1 a–b
17	Structure of the Milky Way: size, shape and constituents of our galaxy; 21 cm radio waves	4.1 c–d
18	The night sky: stars, constellations, clusters etc.	3.1 a–d
19	Observing the constellations: pointers, seasonal constellations	3.1 e–f
20	Size, scale and nature of the Solar System: including scale models	2.1 a–c
21	Orbits: elliptical orbits; ecliptic; zodiacal band; perihelion etc.	2.1 d–i
22	Exploring the Solar System: characteristics of planets, space probes	2.1 j–m
23	Satellites and ring systems: origins of moons, planetary rings	2.1 n–o

Lesson	Content	Specification references
24	The discovery of exoplanets: evidence for exoplanets, difficulties finding them	2.4 a-b
25	The origin of water on Earth	2.4 c-e
26	Extra-terrestrial life? Drake Equation, Goldilocks zones	2.4 f-i
27	The heliocentric Solar System: Copernicus, Tycho and Kepler	2.3 a-c
28	Galileo and his discoveries	2.3 d
29	Gravity: inverse square law nature of gravity, discovery of planets	2.3 e-f
30	Comets and the Oort Cloud: structure, origin and orbits of comets	2.2 a-f
31	Meteors: meteors, meteoroids, meteorites and micrometeorites	2.2 g-i
32	Collision course! PHOs and the hazards that they pose	2.2 j-m
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41	The Universe – past and future: Big Bang, expanding Universe, future models	4.3 n-p
42	Observing the Moon: principal features, lunar rotation	1.2 a-f
43	Exploring the Moon: seas, craters etc and their origin; project Apollo	1.2 g-k
44	Origin of the Moon: Giant Impact Hypothesis	1.2 l-m
45	Lunar phases: the Moon's orbit, phase cycle	1.4 a-d
46	Eclipses: mechanisms for, and durations of, lunar and solar eclipses	1.4 e-g
47	Time: solar day, sidereal day, sun dials, Equation of Time	1.4 h-o
48	Aurorae: the solar wind, mechanism for aurorae	1.4 p-q, 1.3 l

Teaching ideas

The Earth from space: The size, shape and rotation of the Earth

Aims

1. To review the evidence for a spherical Earth and recall the Earth's shape and size.

2. To describe how Eratosthenes made the first calculation of the Earth's circumference.

Specification section	Suggested programme	Resources	Additional notes
	Start (10 minutes) 1. Recap the motion of the Sun in the sky from Key Stage 3 (how the lengths of shadows change during the day and with the seasons). Use a worksheet such as *The Sun in the Sky*. Students could peer mark this before a teacher-led discussion. AND/OR 2. A worksheet similar to the *Shadows and the Sun* starter exercise for students who are more familiar with these concepts could be used to develop basic ideas about the Sun's apparent motion. Peer mark and discussion.	Model globe Metre rule or length of doweling Torch Darkened room	A range of worksheets can be downloaded, free of charge, from www.spacedout-uk.com (click on Resources and then GCSE Astronomy)
1.1a 1.1f 1.1g	Main (40 minutes) 1. Teacher-led introduction to the Earth, its shape and size. How do we know the shape and size of the Earth? This could be through a demonstration (using a globe) or using satellite images of the Earth. Discuss the features of the Earth (water, surface, atmosphere etc).	Model globe Images of Earth	There are some excellent clips from Carl Sagan's COSMOS series available on YouTube.
1.1e 1.1h 1.1i	2. Introduce the work of Eratosthenes who used shadows to determine the angle of the Sun from the vertical at Alexandria at local noon on the date of the summer solstice (June 21st). The Sun was directly overhead at local noon at Syene, a 'known' distance south of Alexandria. Discuss the rotational period of the Earth, the time to rotate through one degree and the following terms: equator, tropics, latitude, longitude, pole, horizon, meridian and zenith.	DVD/video/movie clip of Eratosthenes's 'experiment'	
	3. Students could use the real Sun and a shadow cast by a vertical metre rule, or similar stick, to determine the angle of the Sun from the vertical. OR Demonstrate the technique of determining the angle of the Sun to the vertical in a darkened room.	Map of Middle East region showing Syene and Alexandria	A projection of the region around Alexandria could be projected on IWB using Google Earth.

Specification section	Suggested programme	Resources	Additional notes
	4. Explain how the circumference of the Earth was calculated from Eratosthenes's measurement of angle of the Sun to the vertical and the distance to Alexandria from Syene. Use a worksheet similar to *Measuring the Earth*. **End (10 minutes)** Summary and question/answer session on the main points. **Extension/homework** Students could conduct their own research into the flaws in Eratosthenes's method and data; how could we improve on these today? They could also find out about modern methods used to determine the shape and size of the Earth.	Metre rule(s) or length(s) of doweling Torch	A range of worksheets can be downloaded, free of charge, from www.spacedout-uk.com (click on Resources and then GCSE Astronomy)

Remote Access Robotic Telescopes

Robotic telescopes allow students to extend dramatically the range of observations they can make for their coursework portfolio, almost the same as the professional astronomer! Robotic telescopes are situated at high altitudes around the world where the 'seeing' is much more reliable than in the UK.

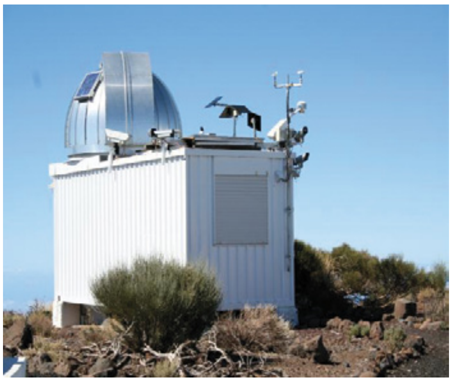
Students should not confuse robotic telescopes with large telescopes which produce galleries of stunning images by professional astronomers. Although these gallery images are an excellent way to support teaching of GCSE Astronomy, they cannot be submitted as part of students' original observations for their internal controlled assessment.

There are currently three main robotic telescopes, all of which are available free to UK centres.

Bradford Robotic Telescope

The Bradford Robotic Telescope (www.telescope.org) is a free resource to aid the teaching of astronomy. There is also a special subscription site (http://schools.telescope.org) which provides extensive teacher and student support for the space-related sections of the curriculum, with other sections linked to teaching science.

The Bradford Robotic Telescope deals with its own scheduling, so there is no need to book a time slot for observations. Activities are complemented by a learning management system and a range of teacher aids. Taking and ordering images is easy and a number of different cameras are available for imaging the night sky. These range from the Galaxy Camera with a field of view of just 20 arc minutes (one third of a degree), suitable for taking images of planets and their moons, galaxies, nebulae, comets and close-up images of the Moon, through to the Constellations Camera whose 40^0 field of view makes it ideal for imaging the constellations and the motion of the planets through the stars.



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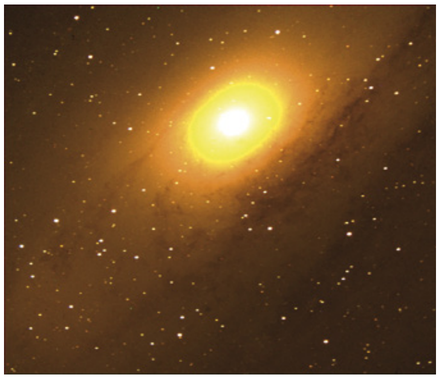


© 2008 Bradford Robotic Telescope

Faulkes Telescope Project

The Faulkes Telescope (FT) (http://faulkes-telescope.com) project provides UK centres with two large (2 m diameter primary mirror) robotic telescopes, equipped with research-grade astronomical instruments and located at professional observatory sites in Hawaii (FT-North: Maui) and Australia (FT-South: Australia). The telescopes are funded by the Dill Faulkes Educational Trust and LCOGTN and are controlled by students over the internet. The telescopes are located in different time zones from the UK, Hawaii (12 hours behind GMT) and Australia (10 hours ahead of GMT), which allows night-time observations to be taken during class hours. Centres can carry out short activities or participate in real astronomical research through the FT's education and research projects. Students can gather data to study objects such as asteroids and comets (maybe even discovering a new one!), colliding galaxies and exploding stars.

The FT website also hosts a Moodle Virtual Learning Environment, full of training resources and activities for teachers and students.

This telescope took this picture.

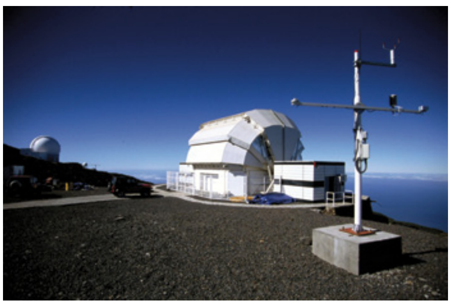
© Images courtesy of the Faulkes Telescope Project/LCOGT. Image processed by Daniel Duggan.

National Schools' Observatory

The National Schools' Observatory (NSO) (www.schoolsobservatory.org.uk) is an internet-based resource providing students with access to a state-of-the-art, research-grade, fully robotic telescope.

The Liverpool Telescope (LT), operated by Liverpool John Moores University, is located on top of an extinct volcano on the island of La Palma in the Canary Isles. The University has allocated observing time for students alongside professional astronomers. Students can observe the night sky through this world class telescope and gather their own data for their coursework projects.

In addition, the NSO website is a rich source of information and activities for students, ranging from using the simple astronomy textbook or simulations of the phases of the Moon to workshops and NSO investigations. The Staff Room section provides teachers with information on available resources and where they can be found on the website.



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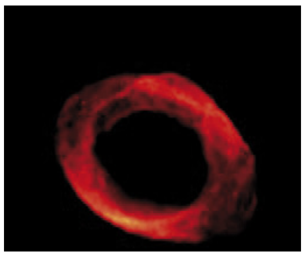


© Dr Robert Smith, Liverpool John Moores University (left)
© Observation taken by the Liverpool Telescope for the National Schools' Observatory (right)

Two astronomy autobiographies

Martin Barstow, Professor of Astrophysics and Space Science at the University of Leicester

'I grew up during the Apollo programme, which really inspired my interest in all things space and astronomy related. I went to secondary school in 1969, and followed the (then) usual curriculum of maths, English, three sciences, a language plus a few other things. To be honest, I really struggled with physics for most of that time. I think the first physics exam I did really well in was when I was 16! I stayed on in the 6th form to do A Levels. We had to choose science or arts (no combinations allowed then) and I was still more interested in science, so I chose maths, physics and chemistry (didn't like biology so much). All that time I was intending to do chemistry at university, but I gradually realised that all the things I was really interested in were in physics. So, although it was not my best subject, I chose to study physics at York University. I still struggled quite a lot, but got a decent degree and was then lucky enough to get a place to study for a PhD in Space Science at Leicester – my dream to work in the space business finally achieved. Following that I was lucky to get a job at Leicester working on a satellite mission and forge a university career in space science and astrophysics as a result. I say I was lucky … but you also have to work really hard and generate a good fraction of your own `luck' to make it!'

Julie Wardlow, Department of Physics, Durham University

'Although I have always been interested in science I was never one of those people who always knew exactly what they wanted to do in life, in fact for a long time I didn't even know you could have a career in astronomy or scientific research! I studied biology, chemistry, maths and physics at AS Level, and, after finding physics more interesting than I expected and biology less so, continued with chemistry, maths and physics to A Level.

By the time it came to deciding what to do after school I had become more interested in 'space' and saw that it was possible to be involved in research by continuing studying after university. With this in mind I did an MSci in Physics and Astronomy at Durham University where I got the chance to spend a summer working in the astronomy groups at Durham and Leicester on a research project. This experience affirmed my decision to do a PhD after my undergraduate degree, which is why I am now still at Durham, in the first year of my PhD, and really enjoying investigating the Universe that I first became fascinated with as a child.'

Student guide

Is this the right subject for me?

Everyone is fascinated by the night sky and our continuing exploration of the Universe. This course will allow you to begin to understand the movements of the bodies in our Solar System in more detail, explaining many of the cycles in the night and daytime sky. It will also allow you to follow the incredible story of how scientists, since ancient times, have used imagination, measurement, and scientific methods to explore the Universe in which we live.

What will I learn?

The material in this course is divided into four sections.

Topic 1 – Earth, Moon and Sun

As well as studying each of these three bodies individually, this topic looks at the interactions between them that cause the familiar cycles of night and day, months and years. You will learn that they are also responsible for less common, but more spectacular, events such as lunar and solar eclipses.

Topic 2 – Planetary systems

Our Universe is composed of billions of stars and over the past century we have begun to realise that many of them may have their own planetary systems. This topic begins with the detailed study of our own planetary system – the Solar System. As well as studying the planets which orbit the Sun, you will also find out about other bodies such as comets and meteors.

Although some of the planets in our Solar System can be seen with the naked eye, others have stretched the abilities of past astronomers and their instruments. This topic looks at the fascinating story of the discovery of these planets. In recent years, modern astronomical technology has discovered some of the planets orbiting other stars.

Topic 3 – Stars

This topic looks at the major constellations in the night sky and how they can be used to find your way around both the night sky and the Earth.

Although the stars seem to remain the same for millennia, they follow a very slow cycle of birth and death. This topic looks at the process of 'stellar evolution', covering stages such as nebulae, red giants, supernovae, neutron stars and black holes.

Topic 4 – Galaxies and Cosmology

Although the early parts of this course focus on our position in the Earth-Moon-Sun system and within the Solar System, we now know that our Sun is just one of billions of stars within the Milky Way galaxy. How this was discovered and what it means for our place in the Universe is covered. The topic ends with the incredible discovery that our Milky Way galaxy is just one of millions in our vast, expanding Universe.

How will I be assessed?

The course is assessed in two sections – Unit 1 and Unit 2.

Unit 1: Understanding the Universe
This section, containing the four topics listed on page 16, is assessed through one two-hour examination paper in June. The paper has a variety of different question types such as multiple-choice questions, short- and extended-answer questions, and graphical and data questions.

The paper is not tiered – it covers all grades from A* to G.

Unit 2: Exploring the Universe
In this section, you will be assessed on the quality of the astronomical observations you complete during the course. You will choose two observational projects, one completed with the naked eye and the other using simple astronomical instruments such as a sundial, a telescope, binoculars or a camera. You will be given a list of possible projects from which to choose. Your observations will be assessed on the quality of their design, observations, analysis and evaluation.

What do I need to know, or be able to do, before taking this course?

All you need to know should have been covered within a Key Stage 3 science course, for example the basic arrangement of the Earth-Moon-Sun system and how this affects us on Earth. You should have some idea of how the movements of these bodies produce effects such as night and day, the phases of the Moon and the seasons.

You will probably know something about the group of planets orbiting the Sun which we call the Solar System. And you will also have learned the basic mathematical skills needed to perform the simple calculations involved in GCSE Astronomy.

What can I do after I've completed the course?

By studying GCSE Astronomy you will be developing important scientific skills as well as extending the range of areas where you use these skills. It is an excellent accompaniment to any GCSE Science course, as well as linking closely with the astrophysical sections within the AS and A2 Physics courses.

Along with the study of AS and A2 Mathematics, these can form the foundation for studying astronomy and astrophysics at university.

Next steps!

If you are considering GCSE Astronomy the pointers below may help you.

- Talk to students in your school or college who are studying or have completed the course.
- Talk to the member of staff in your school or college responsible for GCSE Astronomy to see what is being planned.
- Use the Edexcel website (www.edexcel.com) and follow the links to information about the GCSE course. This will give you up-to-date information about the new GCSE Astronomy course.
- Find out what is happening in the world of astronomy, perhaps by using the regularly updated NASA website (www.nasa.gov) or the Royal Astronomical Society site (www.ras.org.uk).

Assessment overview

The grid gives an overview of the two assessment units for the GCSE Astronomy course. We recommend that you make this information available to students to help ensure that they are fully prepared and know exactly what to expect in each assessment.

All assessments must be completed at the end of the course.

Unit 1	Percentage	Time	Availability	Description
Understanding the Universe	75% (120 marks)	2 hours	June only	**Externally marked written paper:** • single tier, covering all GCSE grades • approximately 20 compulsory questions • answers to questions to be written on examination paper • all Unit 1 content assessed • level of difficulty increases within each question and through the paper • a variety of question styles, including multiple choice, short objective questions, single-word responses, diagram completion, structured questions, simple calculations, data analysis and extended writing. **Students will be expected to use a calculator during the examination.**
Unit 2	**Percentage**	**Time**	**Availability**	**Description**
Exploring the Universe	25% (40 marks)	Suggested 12 hours classroom time plus observation time	June only	**Internally marked controlled assessment, externally moderated:** • two tasks to be submitted – one unaided observation – one aided observation • observations of similar nature are not allowed • each task carries 20 marks • task list supplied by Edexcel, closely linked to Unit 1. **See the controlled assessment guide on *page 26* for further information.**

Examination questions

This examination question guide provides some questions, with answers and examiner comments, to help you familiarise yourself with the requirements of the exam quickly and easily. The four questions cover popular topics and include many that students often find difficult. They illustrate how the level of demand increases through the various parts of a question, and show the range of command words to ensure that your students know what to expect.

Topic 1: Earth, Moon and Sun

Question 1 exemplifies the style and nature of questions found early in the exam paper. It tests basic knowledge and understanding of Topic 1, and focuses on the appearance of and mechanisms for eclipses and lunar phases (*Sub-topic 1.4 Earth-Moon-Sun Interactions*).

1.(a) What is the time period between one full Moon and the next full Moon? Put a cross in the correct box.

A 2.2 days		B 27.3 days		C 29.5 days		D 365 days	

(1 mark)

(b) The diagram shows the Sun and Earth (not to scale). Draw the position of the Moon during a lunar eclipse on the diagram. Use the letter M.

(1 mark)

(c) State the phase of the Moon during a total solar eclipse.

(1 mark)

(d) Explain why a lunar eclipse lasts longer than a solar eclipse.

(2 marks)

Student response

(a) C

(b)

(c) full moon

(d) The Earth's shadow is bigger than the Moon's.

Examiner comment

The responses are typical of a grade C student.

1 (a). The student has correctly marked the lunar phase period of 29.5 days and not become confused with the orbital period of 27.3 days (the most probable distracter). Distracters A and D are not necessary here, and this might have appeared as a similar question (perhaps slightly later in the exam paper) requiring the student to simply insert the correct lunar phase period.

Students often mix up the two types of eclipse and find association with the correct phase of the Moon difficult. In this question, the position of the Moon during a lunar eclipse has been correctly labelled in (b), but the student has confused the full Moon with the new Moon, giving an incorrect response for (c).

1 (d). The student has correctly stated the difference between the relative sizes of the Earth's shadow and the Moon's shadow. This scores 1 mark out of 2. The student has failed to explain the difference in the duration of the eclipses – some reference to the Moon's orbital speed being constant and thus spending more time in the Earth's shadow would have gained the second mark.

It is clear that 2 marks are available for part (d) of this question. These marks cannot be given for one piece of information: the student should ensure that they offer two clearly separate statements in the explanation.

Topic 2: Planetary Systems

Question 2 requires more open-ended responses and deals with material found in *Sub-topic 2.1 Our Solar System*. It illustrates the level of difficulty that students can expect in the middle third of the exam paper and shows progression of demand through the question.

2.(a) The atmosphere of the planet Venus can be used to illustrate the danger of extreme global warming on Earth. Name the gas present in the atmosphere of Venus that is responsible for this.

(1 mark)

(b) State two further key properties of Venus.

(2 marks)

(c) The use of space probes has provided large quantities of data on the planets and other bodies in our Solar System. Choose one such space mission and describe briefly some of the data that it provided for astronomers.

Name of probe

Data from mission

(3 marks)

(d) Describe some of the problems that might be encountered by astronauts during a future manned expedition to Mars.

(3 marks)

Student response

(a) carbon

(b) 1 It spins backwards on its axis.

2 The surface is extremely hot.

(c) name of probe CASSINI/HUYGENS
data from mission Explored Saturn and its moon Titan. Huygens studied Titan and Cassini studied Saturn's rings and other smaller moons.

(d) The astronauts might suffer from muscle fatigue and their bones may become brittle. These would cause problems later on Mars. There would be a lot of boredom on such a long journey and the spacecraft might be struck by an asteroid.

Examiner comment

"The responses are typical of a student working towards a grade C.

2(a). The student has left the name of the gas (carbon dioxide) incomplete and no mark is awarded.

In (b) one key property of the planet Venus has been correctly stated (spinning backwards) but the student's second point does not qualify since it is not a further key property – the high temperature has already been implied in the question with the mention of global warming. Key properties that would have scored the second mark would be: extremely dense atmosphere; extremely high pressure on the surface; mixed terrain of plains and highland regions.

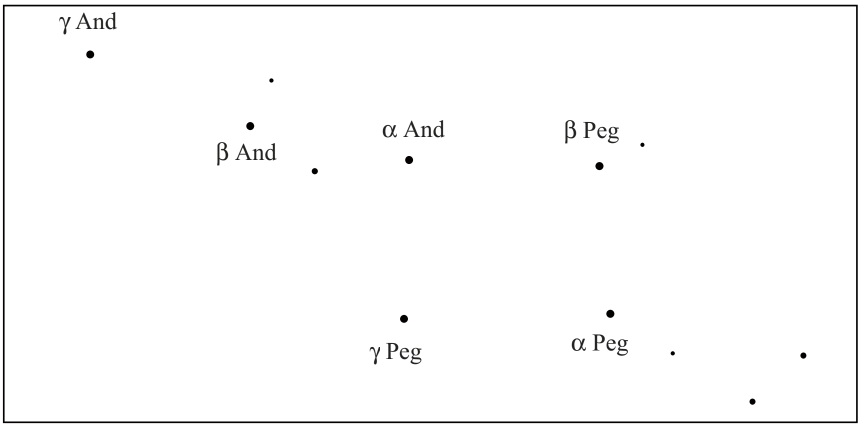
Part (c) scores 2 marks out of 3. The Cassini/Huygens probe has been correctly identified with Saturn and Titan, and these have been distinguished clearly. However, there is only very limited information offered in the student's rather vague response and it does not convey any real awareness of the data returned from this mission. This response is typical of a student who has some idea but who fails to give sufficient detail to back this up.

2(d). Despite the highly improbable asteroid strike (the student may be unaware that the probe would not pass through the Asteroid Belt), three likely problems are clearly stated and the student deserves all 3 marks."

Topic 3: Stars

Question 3 tests a relatively large number of the items in Topic 3 via a number of short-response questions. This question shows the level of difficulty that students might expect in the middle third of the exam paper and illustrates how the level of difficulty increases as the question develops. The question begins with fairly straightforward recall from *Sub-topic 3.1 Constellations* and leads on to testing the concept of magnitudes from *Sub-topic 3.3 Physical Properties of Stars* that many students find difficult.

3. The diagram shows part of the constellations of Andromeda and Pegasus. Some of the stars are labelled.



(a) On the diagram, show:

(i) the position of the Andromeda Galaxy (use the letter A)

(1 mark)

(ii) how two stars can be used to point to the star Fomalhaut (use an arrow).

(1 mark)

(b) The Andromeda Galaxy is visible on a clear night with the naked eye using averted vision. State what is meant by averted vision.

(1 mark)

(c) What is the significance of the letters α, β, γ etc?

(1 mark)

(d) Star β Peg has an apparent magnitude 2.4 and υ Peg (not shown on the diagram) has an apparent magnitude 4.4. How many times brighter than υ Peg does β Peg appear?

(1 mark)

(e) What would be the magnitude of a star that appeared 16 times brighter than γ And (apparent magnitude 2.3)?

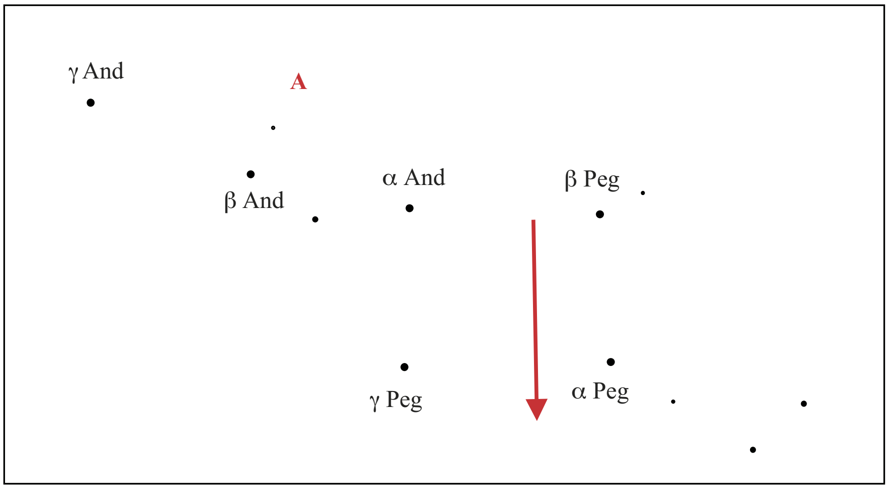
(1 mark)

(f) Two stars have the same apparent magnitude but one star is three times further away from the Earth than the other star. Explain which star would have the greater luminosity.

(2 marks)

Student response

(a)



(b) Looking just to the side of the galaxy to see it properly.

(c) They tell us how bright the stars are.

(d) 6.25

(e) 5.3

(f) The star that was further away would have the greater luminosity because the brightness of a star decreases with distance. To appear as bright as the nearby star it must be emitting more energy.

Examiner comment

"The student has correctly shown the position of the Andromeda Galaxy with the letter A, and despite the arrow being slightly displaced to the right of the stars, it clearly indicates how the two stars can be used as pointers to Fomalhaut.

Response (b) indicates clearly the need to look slightly to the side of this galaxy and deserves the mark.

In (c) although the Greek letters do refer to brightness, the association of alpha with the brightest star, beta with the second brightest etc is not given and no mark is awarded here.

Response (d) is correct and no working out would be expected. The student has correctly associated a three magnitude difference with a brightness ratio of 16, but has unfortunately added 3 to 2.3 instead of subtracting it from 2.3. With 1 mark for this relatively simple task, no mark is awarded.

Part (f) is a response typical of a student heading for grade B or above. It clearly shows an understanding of how distance affects apparent magnitude and is worthy of both marks."

Topic 4: Galaxies and Cosmology

Question 4 involves a calculation and illustrates the highest level of mathematical difficulty that students can expect on a GCSE Astronomy exam paper. This type of question would appear towards the end of the exam paper. It tests knowledge, understanding and application of Topic 4, in particular *Sub-topic 4.3 Cosmology*.

4. (a) Which type of astronomical object can be described as a distant galaxy with a large redshift? Put a cross (X) in the correct box.

A a blazar		B a quasar		C a pulsar		D a supernova	

(1 mark)

(b) An astronomer measures the wavelength of an absorption line in the spectrum of light from a star to be 659.6 nm. If the true wavelength of the spectral line is 654.8 nm, calculate the radial velocity of the star in km/s. The speed of light is 300 000 km/s.

Use the formula: $\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$

(3 marks)

(c) Describe how astronomers use the value of the Hubble constant to determine the age of the Universe.

(2 marks)

Student response

(a)

A a blazar		B a quasar	X	C a pulsar		D a supernova	

(b) 659.6 nm – 654.8 nm = 4.8 nm

4.8 nm/654.8 nm = 0.00733

v = 0.00073 x 300 000 <u>*so v = 2200 m/s*</u>

(c) Hubble's constant is 50 km/s/Mpc and this can be converted into per seconds ie 1/time. This is inverted and this gives the age of the Universe.

Examiner comment

(a). The student has correctly identified a quasar from its description.

The calculation in (b) is correct and shows clear working (always recommended since an incorrect numerical answer could score method marks). Unfortunately, the student fails to gain all 3 marks due to the careless insertion of m/s as the unit and not km/s. This highlights the fact that many students do not appear to realise that the unit is just as important as the numerical value in this type of question.

Part (c) asks for a description and not an explanation. The student has correctly indicated that the Hubble constant has the unit of 1/time and that its value can be manipulated into an age. The correct value based on the most recent measurements is 70 km/s/Mpc or 70 km/s per Mpc - which gives an age of 14 billion years, closer to the true age of 13.7 billion years. Both marks are scored for a difficult concept that is an addition to the specification.

Question 4 illustrates a response typical of a student working towards the B-A grade range. Students below this range might be expected to score the first mark (identification of a quasar) and perhaps gain a method mark for the calculation having made a mathematical error in calculating *v*. They would probably find part (c) difficult.

Controlled assessment

Controlled assessment involves students carrying out observations and is similar to coursework except that controls have been added to ensure the work is all the student's own.

There are three aspects to the controlled assessment: task setting, task taking and task marking. The level of control for each activity in each subject is specified by the regulator.

The regulator have also stipulated whether and how often the task must change.

This section explains the level required for each activity and what it means for you and your students, and the frequency of change.

Task setting

This is very similar to the current arrangements, so it will be familiar.

What is the level of control?

High.

What does this mean?

The tasks are set by Edexcel and are available in the specification.

How often will the task change?

Edexcel will review the tasks every two years. We will look at the task in the light of student performance and make any amendments necessary to make the task clearer.

Any students wanting to retake the controlled assessment unit will need to use tasks available for the session in which they are retaking, regardless of what task they did originally. If students are taking the same task, they must start from scratch, and do the whole task again, or choose an alternative task.

Task marking

This similar to the current arrangements, so will be familiar.

What is the level of control?

Medium.

What does this mean?

You will mark the tasks. You then fill in a form to show all the marks achieved. Edexcel will ask for a sample of the work to moderate, including student work with high and low scores. Edexcel will moderate the work and you will receive a summary report on results day.

Training from Edexcel courses on marking tasks may be available to help you mark the work effectively. Our astronomy experts can also provide support, just email Ask the Expert at www.edexcel.com/asktheexpert

Task taking

The controls for taking the task have been designed to ensure that the task is carried out by the student and is all their own work. This means that students cannot complete the whole task at home and bring it to the classroom. The exception to this is night-time observations and research, where the student can observe and research secondary sources after class hours, unsupervised by the teacher, and then bring the observation and research notes and drawings into class.

The task is split into two parts:

- observations
- design, analysis and evaluation.

The levels of control and the effect are different for each part.

What is the level of control?

Observations: limited

Design, analysis and evaluation: high

What does this mean?

Observations

Observations will be carried out under limited control, including possible night-time unsupervised observations. You will monitor students' work and check that it is their own by benchmarking against previous work and expectations. Research to prepare for the observations can be carried out under limited control, with notes brought into class for the write up of the final report.

Design, analysis and evaluations

Designing the observation sessions and writing the report, including any analysis and evaluation, will take place in the classroom under your direct supervision. The student must not take any information away from the classroom to complete. Students can bring in any notes and diagrams, photographs etc they have made during the observation phase, any data they have collected and any research they have carried out to help with their observations.

You will monitor students in the classroom to ensure that students complete their tasks themselves. You can answer questions but cannot guide students along a particular path or advise on how they should approach the task.

This is not an exam and requires supervision rather than invigilation. There is no need to set up the room like an exam or for the room to be silent. The key requirement is that students are supervised at all times.

The task must be taken during curriculum time.

Controlled assessment exemplars

Exemplar 1: List B – Aided Observations/Project B6 – Sundial

Using the sundial

On a clear sunny day, the sundial was placed on a flat surface. Using a compass it was positioned with the noon-line facing North. At equal intervals the sundial's time (apparent solar time) was recorded on the hour. At these times the mean solar time (on a watch) was also recorded. These results are recorded in the table below (9am, 12 noon, 3pm planned to be used). The results were repeated at 3 times in the year, to test that the sundial was accurate throughout the seasons.

Observational data

	1		2		3	
Date	AST (hrs)	MST (hrs)	AST (hrs)	MST (hrs)	AST (hrs)	MST (hrs)
20/11/2007	09.00	09.09	12.00	12.09	15.00	15.08
20/01/2008	09.00	09.10	12.00	12.09	15.00	15.09
20/02/2008	09.00	09.10	12.00	12.10	15.00	15.08
20/03/2008	09.00	09.09	12.00	12.08	15.00	15.09

Analysis and evaluation

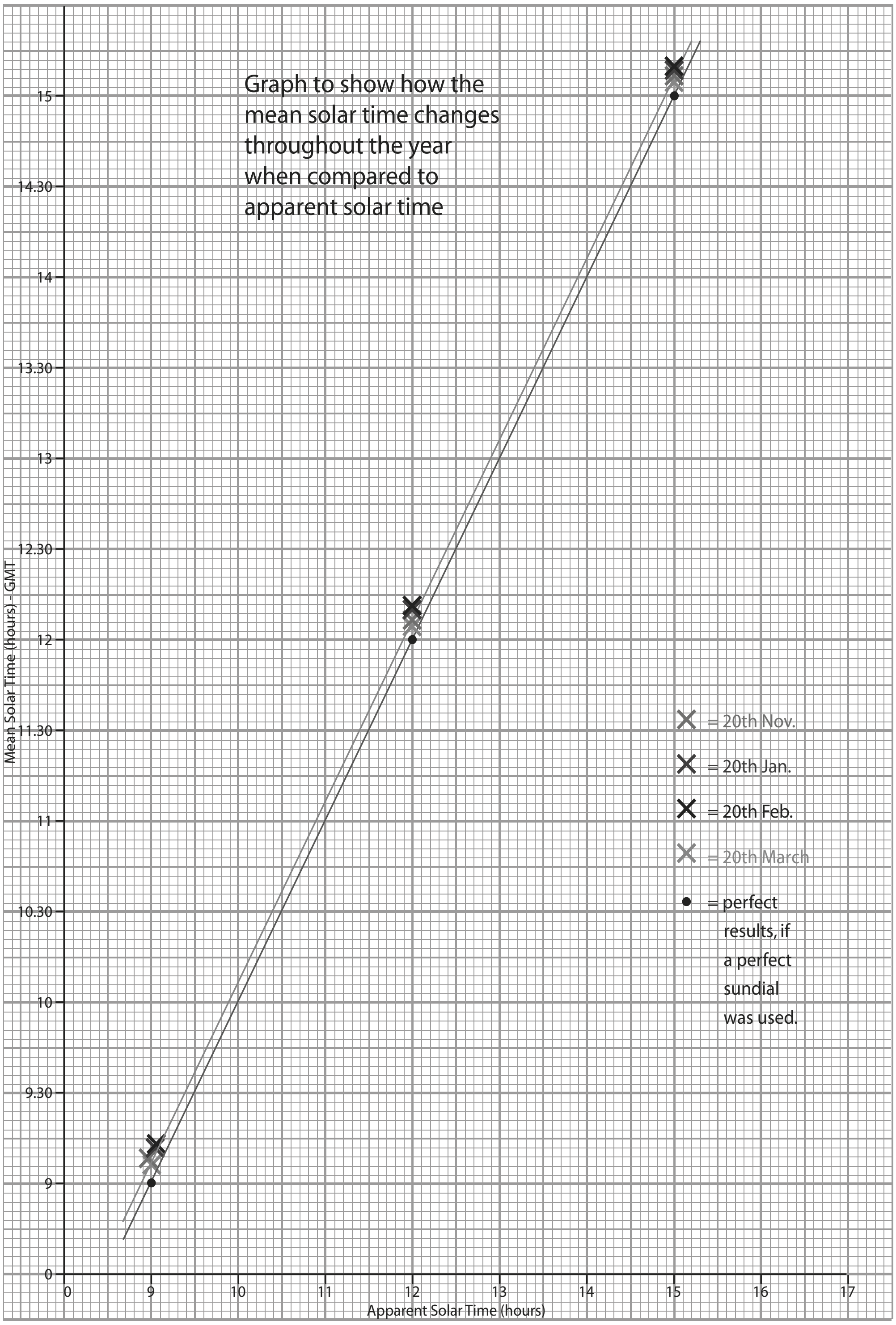
From the results you can see that the sundial is quite accurate. However the sundial has an inaccuracy of approximately 10 minutes. To ensure that these results were accurate I set my watch by the atomic clock at Greenwich Observatory. I placed the sundial on the hill in Greenwich Park, so that there were no shadows from trees or statues.

The error in my results was between 8 and 10 minutes. I tried to measure the sundial time as accurately as possible. However the error could have been caused by the hour-lines being too thick (on the sundial), inaccurate measuring of the angles for the hour-lines and the right angle of latitude.

However, the main reason for the inaccuracy of the results is due to the equation of time. This states that the Earth is different distances from the Sun throughout the year. This can make the sundial up to 15 minutes out of sync with local time (GMT).

I could have tested the sundial over a longer time, rather than a few months. Also the weather conditions would be better in the summer to test the sundial, as sometimes the cloud was covering the Sun, preventing a clear shadow from falling on the dial face.

Overall, I feel that the sundial was well constructed and accurately measured. It performed well when tested and gave quite accurate results. The graph shows that all the results taken throughout the year are very close together. This shows that the error is more likely to be due to the changing distance between the Earth and the Sun, rather than any human error. Also, the results obtained were very close to the 'perfect' results. This shows that my sundial was quite accurate and well constructed.



Moderator marks and comments

“

Marking strand: Design 3/5

Astronomical knowledge has been used to design the programme for testing the sundial, with the importance of a wide range of dates clearly understood. However, it would appear from the description that the sundial has been aligned with Magnetic rather than True North (available from the Pole Star or using an Ordnance Survey map).

The readings have been taken when the sundial is exactly on the hour in question, which is difficult to decide on exactly. A better design would be to take the sundial reading when the clock or watch shows the hour exactly (which can be accurate to the nearest second).

Marking strand: Observations 4/5

As requested by the project description, several widely spaced dates have been chosen and three readings have been taken on each of these dates. Although an even clearer picture of the sundial's accuracy throughout the year could be gained from further readings, the data presented are certainly adequate for their purpose.

Marking strand: Analysis 2/5

A major concern with this analysis is that although the Equation of Time has been mentioned, its value on each of the dates involved does not appear and has not been allowed for when calculating the 'error' in the sundial.

A calculation of the average difference between actual solar time (AST) and mean solar time (MST) on each date, perhaps as an additional column in the table, would also make things clearer.

In this section students should try to avoid using phrases such as 'worked well' and 'quite accurate'. Wherever possible, a numerical value such as 'the average error was 9 minutes' is much more effective.

The explanation for the Equation of Time is incomplete since it results from the inclination of the Earth's orbit as well as its eccentricity.

Marking strand: Evaluation 2/5

Several suggestions for improving the quality of the observational data are given in the short evaluation, although some are rather vague. Nevertheless, the student has correctly suggested taking a wider range of readings during the year.

Several possible sources of error in the sundial are also listed.

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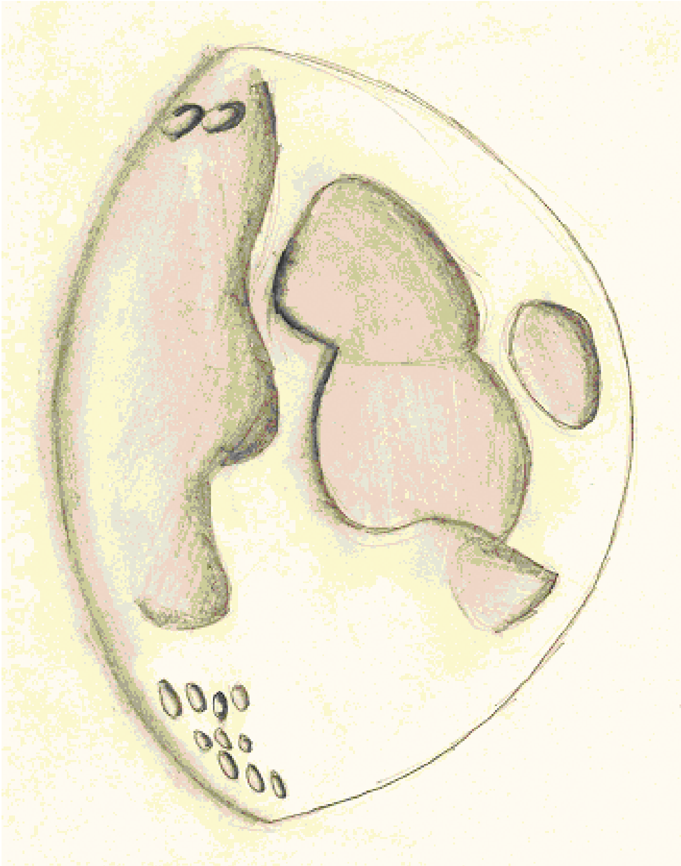
Exemplar 2: List B – Aided Observations/Project B1 – Lunar Feature



The Main features of a Gibbous Moon

Date: February 17th 2005

Seeing/Weather conditions: Some restricted view due to cloud cover

Time: 23.00

Rising Time: 10.31

Setting Time: 03.13

Equipment used:

Binoculars (7x50) with field 7.1˚.

When I drew my observations I decided not to draw from a Full Moon firstly because it is dangerous looking at the Full Moon with an optical instrument such as Binoculars and also because there are no shadows cast when you are viewing the Moon full on. By choosing different views from between a Full Moon and a New Moon you would see shadows cast which shows the landscape that we are looking at and also backs up my statement of task.

As you can see from my readings that I have produced there are a lot of dark patches on the Moon. A lot of these patches are shadows that are being cast. you will notice from my readings and also from other Astronomy books that there are a lot of shadows that are being cast. This leads us to believe that the Moon is very mountainous and due to the shapes of some of the shadows, there are a lot of craters. This is correct. The Moon has no atmosphere due to it's small size and therefore it's low gravity. As there is no atmosphere, when meteorites hit the moon's surface and cause the craters that we can see, there is no weathering or erosion taking place which destroys the evidence of a meteorite crash. If the Earth had no atmosphere it too would look like the Moon.

However there is erosion taking place which covers up the earth's scars.

The dark and apparently flat areas of lunar landscape that are visible are named maria or seas because people used to believe that they were seas on the Moon. 'They are thought to be volcanic features'.

In my first drawing you will notice that there are a group of craters that can just be seen at the bottom. These have been caused from meteorites that crashed into the Moon and have not been eroded.

There are plat planes visible. The almost heart shaped plane is called Mare Tranquillitatis, or the Sea of Tranquillity as it is more commonly known as.

In my second drawing there are again more craters that are visible.

I can conclude that my drawings back up what I have found out about the Moon's landscape and relief from reference books and other sources.

Moderator marks and comments

"

Marking strand: Observations 3/5

The drawings are clear and show effective use of shading. However, only the very largest features of the Moon are shown – almost the same as those which are visible to the naked eye.

Rather more detail would be required for the highest marks in this section. In addition, another couple of drawings would have helped to show the changing appearance of lunar features at different Moon phases more fully.

Most of the major details required for an astronomical observation are included here. However, the observer's location is missing, the time of each observation is not accompanied by its time zone (GMT etc) and the description of the seeing conditions could be improved by use of a numerical scale such as the Antoniadi Scale.

A little more detail about the optical instrument used (7 x 50 binoculars) would be helpful, for example what do the 7 and the 50 stand for and how does this affect its suitability for lunar drawings?

Marking strand: Analysis 2/5

As mentioned above, although they are well-shaded lunar drawings, they do not contain very much detail.

Identifying some of the more prominent features by labelling them with their names would also have gained marks in this section.

"

Improve your coursework – moderator suggestions

Common errors

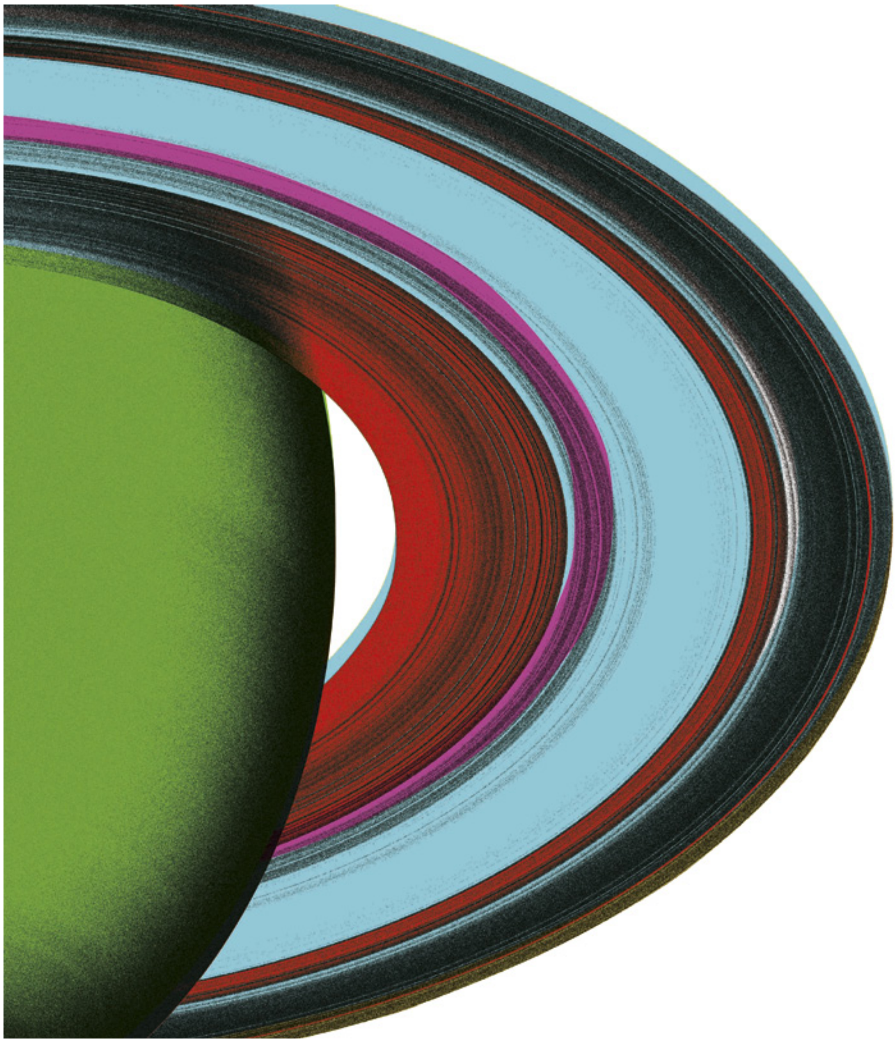
- Students often lose marks by forgetting to include all the necessary, 'observational details' with each of their observations. Every astronomical observation must be accompanied by:
  - location
  - date
  - time
  - weather
  - seeing conditions
  - full details of optical instruments (for aided observation tasks).
- Students often lose marks by making their drawings too small, so that the necessary detail is not clear.
- Students' observational work should show evidence of having been carried out throughout their course. Lower quality work often results when observations are rushed in the final weeks before the coursework deadline, creating gaps, or observations taken when the seeing is poor.

High quality tips

- The essential element in gaining the highest marks for astronomy coursework is the quality of the drawings, data or photographs which are produced. Interestingly, some of the best coursework is often produced by students working with the naked eye. Although more sophisticated equipment allows access to more demanding astronomical objects, producing the best quality results often takes considerable skill and practice.
- High-quality observational work often involves returning to the same celestial object on several occasions, resulting in several sketches of the same object.
- Some of the most demanding marks awarded for astronomy coursework are for analysis. Students aiming for the higher grades should ensure that these features are clearly emphasised in the work which they submit. For example, in the Shadow Stick (A6) or Measuring the Sidereal Day (B12) projects, ensuring that the calculations performed on the observational data are completed accurately, clearly showing how the final values for longitude, sidereal day etc are obtained.

Guidance for unaided and aided observation tasks

All the practical tasks given in both unaided and aided observation tasks are centred around observation, reflecting the work of the professional astronomer. Although both the exemplar pieces of work given above are from the aided observation task, almost all of the accompanying guidance and comment applies equally to the unaided observation tasks.



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